

No. 13.— *The Holothurians of the Museum of Comparative Zoölogy.*  
*The Synaptinae.*

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ALTHOUGH the collection of Synaptinae in the Museum of Comparative Zoölogy is not a large one, it is of much interest not merely because of the undescribed forms which it contains, but because of the light it throws on the range of diversity among specimens of long-known species. Moreover, special interest attaches to some of the material because it was collected and described by Semper, while other species were examined by Selenka and some of this material served as types for forms described in his important monograph on holothurians published in 1867. There are also cotypes of species described by others.

The classification is in fairly satisfactory condition and the study of the M. C. Z. collection does not suggest any changes. The recognized genera seem to be reasonably natural groups although much more material from the East Indian region is needed before the limits of some of them are determined. Specific limits too among the East Indian forms require much clearer indication than the present material permits. The nomenclature seems to have reached a state of considerable stability and questions concerned with it call for no discussion aside from the matter of the validity of certain forms.

The characters upon which the genera and species are based are both external and internal, macroscopic and microscopic, but the most important are the tentacles and the calcareous deposits in the body-wall and tentacles. Each of these demands a few words.

#### THE TENTACLES.

The number of tentacles is typically 12, but in one species it is constantly 11 and in at least one it is 10. Whether any species has normally and regularly 13 tentacles is still to be demonstrated, but in *Synaptula* the number ranges from 12 to 15 and in *S. recta*, it seems probable that 13 is the normal number. *Euapta*, *Opheodesoma*, and *Synapta* have typically 15 tentacles, while *Polyplectana* has 25 as the typical number, though many specimens, particularly small ones, have a much smaller number. As for the form of the tentacles they

are usually considered as of two kinds, *pinnate* and *digitate*, the former having a slender terminal digit and the latter lacking it. It is interesting to find, however, that in the European species of *Labidoplax* there are connecting links between these two quite different sorts of tentacles. For in *L. buskii*, the tentacles have a distinct terminal digit and one digit on each side, while in *L. media*, (unfortunately not represented in the M. C. Z. collection), there are two lateral digits on each side, but no terminal digit.

### THE CALCAREOUS PARTICLES.

Calcareous particles of four kinds occur and as a rule each species has characteristic spicules of each kind, but in certain cases one or even two sorts may be absent.

1. *Anchors*. The anchors are the chief feature of the microscopic anatomy of synaptids and are wanting only in the little-known genus *Anapta*. The size and form of these particles show great diversity, but are remarkably constant within a species and hence furnish one of the best specific characters. In spite of their diversity they have certain features in common, which must be understood, if their value as a taxonomic character is to be appreciated. They lie in the epidermis of the body-wall, outside or over the anchor-plates. The shaft is not straight and the arms and the stock do not lie in the same plane with it. The arms are directed outwards and the stock is bent inwards and as a consequence it is very difficult to get an anchor to lie under the microscope in a perfectly horizontal plane. As a consequence, there is more or less asymmetry in most *camera lucida* drawings and in *microphotographs*, but usually, if the desired position is secured, the anchors are bilaterally symmetrical. Asymmetry, as shown in figures, is not therefore real. In nearly all fully-developed anchors, one of two conditions prevails; either the arms are smooth and there are minute knobs at the apex of the shaft or the apex is smooth and the arms are serrate on the outer side. In young or incompletely-developed anchors both apex and arms are smooth. Another important character is noted in the stock, which may be deeply divided, even somewhat branched, or on the other hand is not divided at all, but is covered along and near the margin by minute teeth or prickles. Good generic characters are given by the four possible combinations of these two features.

2. *Anchor-plates*. The anchor-plates lying below the anchors and serving as a support for them, to which are attached by the stock, are

very difficult objects to show in drawings. The outer surface is more or less concave, in most cases, and there is a fairly evident, but not clearly defined, thick rim around the plate except at the narrower end. In *Euapta* and *Opheodesoma* there is a well-marked arch across this narrow end, on the outer side, called the "bridge." This bridge is also evident in *Synaptula*, less so in *Synapta*, while in *Leptosynapta* it tends to become fused more or less fully with the plate. It is wanting in *Labidoplax*, but is represented in *Protankyra* by an irregular mass not at all like the slender bridge of *Euapta*. The perforations in the plate are rarely smooth and entire in adults, but always are so in the incompletely-developed plates. In the most specialized plates, such as those of *Euapta*, the serrations are on one surface of the plate on one side of the opening and on the other surface of the plate on the other side. In *Opheodesoma*, there is a tendency for the serrations on the outer side of the plate to completely surround at least some of the perforations. Excellent taxonomic characters are thus given by the condition of the bridge and the serrations, as well as by the form of the plate.

3. *Supporting rods*. In most synaptids, the walls of the digits or of the tentacles or of both, are supplied with calcareous rods, which furnish a fairly good taxonomic character. The absence of these rods is one of the distinguishing features of *Opheodesoma*, *Polyplectana*, *Synapta*, and *Synaptula*.

4. *Miliary particles or granules*. In most genera there are present very minute rods, grains, plates, or particles of lime which are conveniently termed miliary particles. When best developed they occur in patches in the epidermis, often around the anchors and plates, and are visible to the naked eye as white blotches on the skin. If less well developed they are scattered uniformly or more or less irregularly in the skin and are not visible except with considerable magnification. When least developed they are found only along the radii and sometimes only near the anterior end of the body. They may be wholly wanting. They are fairly characteristic in the different genera and in *Leptosynapta* and *Protankyra*, at least, they furnish excellent specific characters. When the form is distinctive, the miliary particles furnish one of the most reliable means of identifying species.

There are 710 specimens of 35 valid species in the M. C. Z. collection. Several invalid species, represented by type-material, naturally have also to be considered. The measurements given of the calcareous particles are calculated from sketches made with a *camera lucida*, after magnifications of 95 or 425 diameters. They are of course based

on normal, fully-developed particles. The figures given are all drawn to the same scale, in order to facilitate comparison between allied species. Particular attention has been given to the anchor-plates in the effort to show the exact character of the serrations around the perforations and the nature of the so-called "bridge." Such detailed figures have not hitherto been published.

EUAPTA GODEFFROYI.

Plate 1, fig. 1-4.

*Synapta godeffroyi* Semper, 1868. Holothuriën, p. 231.

*Euapta godeffroyi* Östergren, 1898. Öfv. K. vet.-akad. Forh., 55, p. 113.

There are 12 specimens of this Indo-Pacific species from five localities. Four specimens were collected by Garrett at the Hawaiian Islands and were examined by Selenka. There are several labels with them; one reads "*Synapta serpentina*. Sandwich Islands. 1065," another "*Synapta serpentina* Mull. (as named by Selenka)." Selenka, however, records no *serpentina* from the "Sandwich Islands," but lists only a Zanzibar specimen as in the M. C. Z., so he may not be responsible for this misidentification. The specimens are unquestionably *godeffroyi*, but there are none in the M. C. Z. which can properly be called *serpentina* so I am unable to distinguish that species from *godeffroyi*. The four Hawaiian specimens of the latter range from 230 to 475 mm. in length; the largest is 20 mm., more or less, in diameter and in life was probably over a meter long. It has 16 tentacles with as many as 40 pairs of digits, about 30 polian vesicles and a single stone-canal. Color, pale brown, nearly white anteriorly, darkest posteriorly and dorsally; posteriorly, ventrally, dark, radial lines are well marked. Calcareous ring distinctly greenish in color. Cartilaginous ring wanting. The other three specimens have 15 tentacles each, with 20-30 pairs of digits. The coloration is similar, but in the two smallest specimens is much darker. In all the green color of the calcareous ring is notable.

A specimen from the Marshall Islands, 230 mm. long, has 15 tentacles, but they are very small, only 7-8 mm. long, or about one half the normal size. Its color is nearly white except for dark spots about 3 mm. in diameter, apparently in transverse series on the back, though the arrangement is obscure. There is no indication of "eye-spots" at the base of the tentacles on the disk. The calcareous ring is green-

ish. Cartilaginous ring wanting. One stone-canal, but very many polian vesicles. The miliary granules are excessively abundant in this specimen and its white color is, in part at least, due to them.

A specimen from Samoa is one of Semper's cotypes, and is apparently the specimen from which his figure of the calcareous ring was taken, as that much of the ring, which is conspicuously green, is carefully exposed. The specimen is 470 mm. long and has numerous polian vesicles, but only one stone-canal. The color is whitish, somewhat variegated dorsally with pale and darker brown.

A specimen taken by Garrett at the Society Islands is 190 mm. long and 9 mm. in diameter, and has 15 tentacles with 25-30 pairs of digits. It is variegated pale and dark brown and has the calcareous ring green. The miliary granules are very numerous, especially on the inner face of the tentacles, at the base of which are at least faint indications of eye-spots. The polian vesicles are numerous and the stone-canal single.

Other specimens are from Hawaii, Samoa, and the Murray Islands, northeastern Australia. They range from 120 to 290 mm. in length. All have 15 tentacles, but the number of digits ranges from 17 to 32 pairs. There are distinct eye-spots in the specimens from Samoa and the Murray Islands, but none in the Hawaiian specimens, which may be accounted for in part by the fact that the former have been in alcohol less than ten years while the former were taken in the "fifties" and have been in alcohol of more or less variable strength ever since. There are 15 or more polian vesicles and a single stone-canal in each of these specimens. In the smallest, the calcareous ring is not at all green, but in the others it ranges from greenish to apple-green, and in the Murray Island specimen even the madreporite is greenish.

The calcareous particles of *godeffroyi* are distinctive and quite constant in forms. The anchors and plates are typical of the genus. In the key to the species of *Euapta* in my *Apodous holothurians* (1908), *godeffroyi* is distinguished from the West Indian species, *lappa*, by the presence of misformed anchors, which I have never seen in the West Indian *Euapta*. But examination of the M. C. Z. material of *godeffroyi* shows that this is not distinctive as not a single malformation of an anchor has been detected in any specimen! The real difference between the East and West Indian species of *Euapta* is in the size of the anchors and plates. In *godeffroyi* the anchors range from 275 to 380  $\mu$  in length with an average size of about 325  $\mu$ . The anchors in the posterior part of the animal are a trifle larger than anteriorly, but the difference seems to be very insignificant. The arms of the anchor

are about 22% as long as the whole anchor, while their width is about 50%. In *lappa*, on the other hand, the anchors range from 300 to 440  $\mu$  with the average at least 380  $\mu$ . The arms of the anchors, moreover, are over 30% of the length and their width 57%. The anchor-plates in each species are about two thirds as long as the anchors, but in *godeffroyi* the width of the plate is about 70% of its length while in *lappa* the plates are a trifle narrower, the breadth averaging only 64% of the length. The miliary granules of *godeffroyi* are nearly spherical or perhaps somewhat discoidal and only about 20  $\mu$  in diameter. No noteworthy differences in the calcareous deposits of specimens from different localities were seen in *godeffroyi*, but it does seem as though smaller anchors and plates occur in the smaller specimens and the largest deposits in the largest specimens. Thus a specimen from Hawaii, 120 mm. long, has anchors 280–310  $\mu$  long while another of the same lot, 420 mm. long, has the anchors 340–370  $\mu$ , and Semper's cotype from Samoa, which is 470 mm. long, has some anchors 380  $\mu$ .

The M. C. Z. material shows then that *godeffroyi* is to be distinguished from others which it superficially resembles, first, by its anchor-plates which are typical of *Euapta*, and secondly, by the anchors which are smaller than those of *lappa* and have shorter and slightly less extended arms. Another interesting and apparently useful character for distinguishing *godeffroyi* among its East Indian relatives is the more or less green calcareous ring. The presence or absence of eye-spots on the oral disk seems to be a very unreliable feature, though it is probable they are regularly present in normal living adults.

#### EUAPTA LAPPA.

Plate 1, fig. 5–7.

*Synapta lappa* J. Müller, 1850. Müller's arch., p. 134.

*Euapta lappa* Östergren, 1898. Öfv. K. vet. akad. Forh., 55, p. 113.

There are 32 specimens in the M. C. Z. of this West Indian species. They come from Florida, Jamaica (Montego Bay, Port Antonio and the vicinity of Port Royal), and Tobago. They range from 100 to 480 mm. long in their preserved condition, but the largest could undoubtedly extend itself to a meter when alive, and that is probably the maximum for the species. Of the 29 specimens in which the tentacles are present and can be counted, 25 have 15 tentacles and 4 have 14. In a specimen from Montego Bay one tentacle is much smaller than the other 14; in another, two tentacles, (on opposite sides of the circle),

are only 7 mm. long, while the other 13 are about 16 mm. long. The number of digits increases with age; in most of the Jamaica material there are 20-22 pairs, but in the largest specimen, which is from Tobago, there are 27-30 pairs. As in *godeffroyi* the calcareous ring is more or less green, there is a single stone-canal and the polian vesicles are very numerous. The cartilaginous ring is wanting, though there is considerable tough connective-tissue below the calcareous ring.

The calcareous particles are almost exactly like those of *godeffroyi*, but as explained under that species the anchors and plates are distinctly larger and their relative proportions are somewhat different. The figures (Pl. 1, fig. 1, 2, 5, 6) show the degree of this difference. As in the East Indian species, so in *lappa*, the anterior anchors are not noticeably larger than the posterior anchors of the same specimen, but in the larger specimens, just as in *godeffroyi*, the anchors and plates are appreciably larger than in small specimens; thus in the largest specimen (480 mm. long) the anchors average 410  $\mu$  while in the other Tobagoan which is only three fourths as large the average is 360  $\mu$  and in still smaller specimens the average is only a little over 340  $\mu$ . Moreover there is a fairly striking difference between the specimens from Tobago averaged together and large specimens from Montego Bay, in that the anchors of the former seem to be distinctly larger.

#### OPHEODESOMA GLABRA.

Plate 2, fig. 4-6.

*Synapta glabra* Semper, 1868. Holothuriën, p. 12.

*Opheodesoma glabra* Fisher, 1907. Hawaiian hol., p. 723.

There are only two specimens of this species in the collection and each of these has features of special interest.

One is from SIBOGA St. 213, near Saleyer, D. E. I. and was identified by Sluiter. It is 215 mm. long and has 15 tentacles, each with about 22 pairs of digits. The calcareous ring is low, white, without a trace of green. Stone-canals and polian vesicles both numerous. The genital duct, in the mesentery, is notably long. On the oral disk are two minute eye-spots at the base of each tentacle. There is no cartilaginous ring and there are no supporting rods in the tentacles. The color is brown, darkest above, lightest below, not mottled. The body-wall is smooth to the touch.

The other specimen is from Luzon, Philippine Islands, but no more definite locality is given. It is 230 mm. long and apparently has 15

tentacles, but they are too much contracted to make an accurate count possible. The calcareous ring is tinged with green. Stone-canals and polian vesicles both numerous. The genital duct is not notably long. There are no eye-spots. The cartilaginous ring is well developed, opaque, white, with no openings in it below the calcareous ring. There are no supporting rods in the tentacles. The color is almost uniformly dark gray and the body-wall is slightly rough.

In view of the differences in color, body-wall texture, calcareous ring, eye-spots and cartilaginous ring, it might well be argued that these two specimens are not the same species, but the calcareous particles are identical and until more material is available, it is inadvisable to lay too much stress on differences in other characters.

The anchors in *glabra* show little difference in size according to the part of the body where they are examined; thus those from the dorsal side anteriorly, in the Saleyer specimen, measure about 263  $\mu$ , from the dorsal side posteriorly about 260  $\mu$ , ventral side anteriorly about 274  $\mu$ , and ventral side posteriorly about 260  $\mu$ ; in all four regions they run from 260 to 275  $\mu$ . The anchor-arms are about 36% of the length of the anchor and their width is about 50% of it. The anchor-plates are about 213  $\mu$  long by 177  $\mu$  wide; that is they are about 80% of the anchor-length and their breadth is about 83% of their own length. Whether there are locality differences remains to be seen; there is no indication of it in these two specimens. Miliary granules in *glabra* are similar to those in *Euapta*, but are smaller as in the other species of *Opheodesoma*.

#### OPHEODESOMA GRISEA.

##### Plate 2, fig. 1-3.

*Synapta grisea* Semper, 1868. *Holothurien*, p. 11.

*Opheodesoma grisea* Fisher, 1907. *Hawaiian hol.*, p. 723.

There are six specimens of this species in the collection, all but one from Mer, Murray Islands, northeastern Australia. The largest of these is 650 mm. long, but the head-end is in poor condition and while 15 tentacles can be counted, the number of digits thereon is uncertain and the calcareous ring and its associated organs are wanting. A second specimen is 530 mm. long and has 15 tentacles of which those on the right dorsal side are 25 mm. long and those on the left ventral are 15 mm. There are about 32 pairs of digits in the longer ones. The calcareous ring, which is slightly tinged with green, is like that of *glabra*, as shown in Semper's figure (1868, *Holothurien*, Pl. 4, fig. 8a).

The cartilaginous ring is very well developed, white, and opaque, with a circular foramen under each piece of the calcareous ring, both radial and interradial. Polian vesicles and stone-canals are both numerous. There are no eye-spots nor are there supporting rods in the tentacles. The color is variegated light and dark brown, the darker shade forming indistinct wide transverse bands.

The other specimens are 400–460 mm. long and are very similar to the larger one, having 15 tentacles, conspicuous cartilaginous ring, etc. In one specimen, one of the tentacles is rudimentary but does not seem to be regenerating. The color of these specimens is similar to the large ones, but the transverse dark bands are not equally distinct in all.

The anchors range from 275  $\mu$  to 357  $\mu$  and average about 315  $\mu$ ; the arms are about 35% of the length but their width is 65–80 % of that length. They are thus actually larger and relatively much wider than in *glabra*. The anchor-plates are relatively smaller than those of *glabra* as they are about 73% of the anchor-length and their width is about 77% of their own length. Both anchors and plates show slight differences in details from those of *glabra* as will be seen in the figures given (Pl. 2, fig. 6). The miliary granules of *grisea* (Pl. 2, fig. 3) are similar to those of the other species of *Opheodesoma*.

The sixth specimen is from Zanzibar. It is 700 mm. long and lacks the head-end. The color is variegated with different shades of brown, but is more or less bleached by the long stay in alcohol. The anchors and plates are like those in the specimens from Mer, and hence, although it is labeled *serpentina*, it must, I think, be referred to *grisea*. The anchors are a little over 300  $\mu$  in length and their width is about 70% of that length; they are thus a trifle smaller than in the Murray Islands specimens.

#### OPHEODESOMA SPECTABILIS.

Plate 2, fig. 7–9.

Fisher, 1907. Hawaiian hol., p. 723.

There are 29 specimens of this species at hand, all from Pearl Harbor, Oahu, Hawaiian Islands. Of these, 3 are cotypes of Fisher's and 26 were collected by myself in December, 1913. There are two in which the number of tentacles cannot be determined satisfactorily, but the others each have 15. In general these specimens accord well with Fisher's description and figures. In two specimens, there are only 12 tentacles fully developed, the other three being more or less rudimentary. Many stone-canals and polian vesicles are present,

save in one specimen where there are only a few polian vesicles. There is great diversity in the matter of the cartilaginous ring, but in general it may be said to be wanting in very small specimens and heavy in those that are full grown. There is an equally striking difference in the size of the calcareous particles between young and old. In a specimen 40 mm. long (probably 75-80 mm. long in life), the anchors average only about  $232 \mu$  in length, in one 100 mm. long, they run about  $295 \mu$ , and in specimens 160-200 mm., they average  $326 \mu$ . In full-grown adults, they often exceed  $400 \mu$  and average about  $385 \mu$ . The arms of the anchors are about one third as long as the anchor, but their breadth is two thirds of that length. It will be noted therefore that the calcareous particles afford very little assistance in distinguishing *spectabilis* from *grisca*. The most that can be said is that if specimens of the same size are compared, the Hawaiian species will be found to have anchors about 10% longer than the other and their arms will be relatively less broad.

#### POLYPLECTANA KEFERSTEINII.

Plate 1, fig. 8-12.

*Synapta kefersteinii* Selenka, 1867. Zeitsch. f. wiss. zool., **17**, p. 360.

*Polyplectana kefersteinii* H. L. Clark, 1908. Apod. hol., p. 16, 77.

There are 23 specimens of this interesting species, including cotypes. They vary greatly in size and in number of tentacles, but they leave little room for doubt that the typical adult *kefersteinii* is 400-500 mm. long (in life) at least, and has 25 tentacles; specimens, however, undoubtedly grow to a greater size and may have 26 or 27 tentacles, possibly more.

The cotypes are 6 specimens from the Hawaiian Islands, several of which are more or less fragmentary. They are 95-150 mm. long, a typical one being 135 mm., and 9 mm. in diameter. In one case the tentacles are lacking and in another they can be counted only with difficulty, but there are apparently 25. Of the others, one has 22, one 23, one 25 and one, 140 mm. long, 26. These specimens are uniformly brown. The miliary granules are rods 17-35  $\mu$  long, usually expanded and notched or even branched at one or, generally, both ends. The anchors are appreciably larger in these cotypes than in any other specimens of *kefersteinii* I have examined. They are  $310 \mu$  long, with the arms only  $22\frac{1}{2}\%$  of the length; the breadth of the short, thick arms is fully 60% of the anchor-length. The plates are not so large as in

some other cases, but are about  $220\mu$  long and  $160-175\mu$  wide. Miliary granules are fairly abundant, but there are none in the tentacles.

An anterior fragment of a specimen from Samoa, 33 mm. long and 7 mm. in diameter, received from Semper, has also been examined by Selenka, though it is apparently not a cotype. There are only 21 tentacles, which are rather long, but with 15-17 pairs of short digits. The calcareous ring is rather thin, with no trace of green, and the cartilaginous ring is also thin, but very wide. There is one stone-canal and many polian vesicles. The miliary granules while occasionally rod-like, as in the cotypes, are as a rule expanded into little imperfect rosettes or asymmetrical perforated plates. At the very tips of the tentacles, however, are numerous, minute, rod-shaped or oblong granules only  $6-10\mu$  long. The anchors average about  $260\mu$  long with arms only  $68\mu$  long but  $160\mu$  across. The plates are about  $210\mu$  by  $165\mu$ .

An old specimen, pale brown, but more or less bleached, about 140 mm. long, with 26 tentacles, is said to be from the "Isle of Pearls, Panama" but I do not credit the label. It is probable that the Hawaiian Islands is the correct locality. The anchors are about  $280\mu$  long, with arms about  $77\mu$  long and  $170\mu$  across. The plates are about  $210\mu$  by  $165\mu$ .

There are 2 specimens about 110 mm. long from Lahaina, Maui, Hawaiian Islands, which I collected December 6, 1913. They are uniformly purple-brown in color and have 25 and 26 tentacles. The anchors in one specimen are  $263-277\mu$  long, while in the other they are about  $300\mu$ . The plates with the smaller anchors are only  $190-200\mu$  long, while those of the other specimen are about  $215\mu$  by  $165\mu$ .

There are 7 specimens, which I found at Hilo, Hawaii, December 8-10, 1913. They vary from 35 to over 200 mm. in length; the smallest is only 2.5 mm. in diameter while the largest is 17. The number of tentacles shows great diversity and is not closely correlated with size. A specimen 90 mm. long has only 16 subequal tentacles; one, 60 mm. long, has 20 tentacles; the little 35 mm. specimen has 22; one, 75 mm. long, has 23; the largest specimen and another, 160 mm. long, have 25 each; and a specimen 95 mm. long has 27 tentacles, but 3 are undigitated stumps and 3 others are noticeably smaller than the rest. In the specimen with 20 tentacles, 2, side by side, are undigitated; the specimen with 22 has one much smaller than the rest; and the one with 23 has one undigitated and 2 others much smaller than the others. The smallest specimen has very distinct "eye-spots" on the oral disk and the calcareous particles are very small; the anchors are

200–215  $\mu$  long and their arms are relatively long for the species, 26% of anchor-length, but the breadth of the arms is about as usual, 60% of anchor-length; the plates are mostly about 145  $\mu$  long by 130–140  $\mu$  wide, but some were found notably larger, 188  $\times$  158  $\mu$ ; many anchors and plates are in the well-known stages of development, beginning with simple rods and x-shaped bodies, an obvious indication of the youthfulness of the specimen; the miliary granules are very minute discoidal bodies often, but not always, with one or two handle-like projections and when two such projections occur, the granules might be described as rods with a disk-like enlargement at the middle. The specimen 90 mm. long has the miliary granules all rods, often enlarged at middle or near one end; the anchors are about 260  $\mu$  long with arms not quite one fourth as much, while the plates are about 200  $\times$  158  $\mu$ . The largest specimen is over 200 mm. long, uniformly brown, lightest on the tentacles, the inner surface of which is sparsely speckled with dark brown. The tentacles are about 12 mm. long and have about 30 pairs of digits. The miliary granules are excessively abundant so that at middle of body the anchors and plates are actually imbedded in them. The anchors are about 290  $\mu$  long with the arms fully 26% of the length and the breadth well over the usual 60%; the plates are 220–235  $\mu$  by 167–180  $\mu$ .

A specimen which I collected on the reef at Papeete, Tahiti, August 5, 1913, is in fragments, but has a diameter of about 7 mm. It has only 18 tentacles and 3 of these are very small and 2 others smaller than the rest. The miliary granules are bent, branched and contorted rods, of rather unusual stoutness. The anchors are about 260  $\mu$  long, with long arms 26% of anchor and having a spread of 62% of anchor-length; the plates are 200  $\times$  158  $\mu$ .

From Mer, Murray Islands, northeastern Australia, there are 4 specimens, 70  $\times$  7 mm., 165  $\times$  13 mm., 300  $\times$  17 mm., and an anterior fragment, 8 mm. in diameter. These specimens were collected on the reef-flat at Mer in October, 1913. The smallest has 23 tentacles, with one smaller than the others; the two next larger have 24 tentacles, in each case with 2 small ones; the largest specimen has 25 equal tentacles. All these specimens are brown, in one case distinctly darker dorsally; the tentacles are more or less conspicuously speckled except in the largest specimen, where they are reticulated with brown. The miliary granules are very numerous and are nearly all more or less plate-like, much as in the specimen from Samoa. In the largest *kefersteini* I have seen, the plates are very large, but the anchors are not so big as in the cotypes; they measure about 300  $\mu$  in length with

the arms having the unusual length of  $27\frac{1}{2}\%$  of the whole, but the usual breadth of about  $62\%$ ; the plates measure up to  $242 \times 190 \mu$ , very probably the maximum for the species.

There is an anterior end, 10 mm. in diameter, from Tutuila, Samoa, collected in 1917 by John W. Mills. It has 25 much-contracted tentacles and normal calcareous particles of the average size.

#### SYNAPTA MACULATA.

Plate 3, fig. 1, 2; Plate 4, fig. 1; Plate 5.

*Holothuria maculata* Chamisso and Eysenhardt, 1821. Nov. Act. Acad. Germ. 10, p. 352.

*Synapta maculata* Jäger, 1833. De Holoth., p. 15.

There are 21 specimens of this very interesting holothurian from the following localities: Zanzibar; Port Galera, Philippine Islands; Hope Island, Great Barrier Reef, Australia; Mer, Murray Islands, north-eastern Australia; Nukulau, Fiji; Moala, Fiji; Gilbert Islands; Tutuila, Samoa; Papeete, Tahiti.

The single specimen from Zanzibar is only an anterior fragment and shows no peculiarities worthy of note. It seems to be indistinguishable from Pacific specimens. The six specimens from Port Galera are typical though by no means full grown. They are 180–600 mm. long, indicating a length in life of about twice as much. All are dark colored, either dark reddish brown and blackish or dark grayish brown and blackish. Each has 15 tentacles and numerous polian vesicles and stone-canals, often on both sides of the mesentery, though more generally on the left. The cartilaginous ring is very markedly developed, so that the calcareous ring is more or less buried in it. It has circular foramina more or less developed near its posterior margin. The calcareous ring is white without any trace of green. It is one fourth to one third as high as the complete cartilaginous ring. There are no supporting rods in the tentacles, but very minute and irregular miliary granules are abundant there, usually in patches or in continuous lines along the sides of the digits near the tip. Similar granules are excessively abundant in the skin of the body. They are only about  $10\text{--}15 \mu$  in diameter.

The specimen from Hope Island is about 700 mm. long, and has 15 tentacles with 32–37 pairs of digits. The five Murray Islands specimens are relatively small, about 250 mm. and have 15 tentacles each with 24–39 pairs of digits. The two specimens from Nukulau are

about the same length, but are much stouter and were no doubt much larger in life. The specimen from Moala is not noteworthy.

The Gilbert Island specimen is of considerable interest. It is only a little over 150 mm. long and although now bleached of all distinctive color, it is labeled *agassizii*. The anchors and plates are small and resemble those of the smallest one from Tahiti, described below. The specimen from Tutuila is typical, 15-tentacled, and of average size.

The three specimens from Papeete are also of much interest, and require special description. Two are the types of *Synapta agassizii* Selenka and show the coloration on which that supposed species was based. One of them is of average size and aside from the coloration is not unusual, but the other is the smallest specimen of *maculata* which I have seen, 150 mm. long, and shows growth-changes in the calcareous particles which are of great interest. Anteriorly the anchors and plates are typical though somewhat smaller than usual, the anchors measuring 680-740  $\mu$ , but posteriorly while a few of the deposits are as large as this, most are much smaller, the anchors being only 335-560  $\mu$  long, and the plates, although perfectly formed, are only 240-300  $\mu$  long by 175-190  $\mu$  wide and the margins of the holes are more or less dentate. The original deposits therefore are apparently much more like the familiar *Leptosynapta* type, than one would suppose from examination of an adult specimen. Even the anchors show to some degree an approximation to the *Leptosynapta* form, though the approach is not nearly so striking as with the plates.

The third specimen, from Papeete, Tahiti, is only a fragment of a very large specimen, well over a meter in length, which I collected August 5, 1913. As only a small amount of alcohol was available for its preservation, I made no attempt to keep the whole specimen, but merely kept the fragment, now before me, to provide a sample of the calcareous deposits that I might make sure the animal was undoubtedly *Synapta maculata*. Examination of these deposits shows them to be quite unusual and suggests the possibility of a second species of the genus existing at Tahiti. The anchors are not remarkable, but the plates (Pl. 5) are oval instead of oblong, about 735  $\mu$  long by 500  $\mu$  wide, the bridge is often incomplete and may be wanting, the large perforations are at the larger end and the margin of the plate is more or less irregular and incomplete. Since the specimen is so fragmentary, and it is not impossible that these plates are merely senescent, it would not be wise to regard them as indicative of a new species, but they are certainly very suggestive, as I have seen nothing approaching them in form in any *Synapta* examined.

The typical deposits in *maculata* are very characteristic. The anchors are 850–1160  $\mu$  in length and hence are easily visible to the naked eye. The arms are about 35–40% of the length while their breadth is about 65% of the anchor-length. The stock is not branched, but finely toothed along its margin, much as in *Leptosynapta*, and the arms are perfectly smooth. Usually there are some very minute spherical knobs at the apex, either in a single central series or in a short series on each side, but sometimes these are wanting even in anchors which seem otherwise to be fully developed. The anchor-plates are almost oblong, about 700  $\mu$  long by 350  $\mu$ , but the sides are not quite straight and parallel, the greatest width being evidently back of the middle, at the point where the 8 or 9 large holes occur in the plate. The number of small perforations may exceed 50. All holes, large and small, have smooth margins. The bridge across the lower end of the plate is not prominent or well developed but it is usually distinct.

#### SYNAPTULA HYDRIFORMIS.

Plate 3, fig. 5, 6; Plate 4, fig. 4.

*Holothuria hydriformis* Lesueur, 1824. Journ. Acad. nat. sci. Phil., 4, p. 162.  
*Synaptula hydriformis* H. L. Clark, 1908. Apod. hol., p. 23, 82.

There are 208 specimens of this species from the following localities—Bermuda: Hamilton Harbor, Fairyland Bay, and Hungry Bay; Florida: Woman Key, Loggerhead Key, and Key West; Jamaica: Port Royal “lakes,” Umbrella Point (near Montego Bay), and Bognu Islands, Montego Bay; Tobago: Buccoo Bay. These specimens range in size from those just born, 2–3 mm. in length, up to full-grown adults, 75 mm. long in their preserved condition. The ordinary anatomical features of this species are so well known it is unnecessary to discuss them here, but some points in regard to the calcareous particles warrant a few words.

Comparison of specimens from the various localities revealed no differences of importance in the size of the anchors or plates, nor do there seem to be any differences associated with the part of the body-wall where the particles lie. But there are some notable growth-changes worthy of record. In a specimen 3 mm. long, the anchors are about 130  $\mu$  in length and the plates are 115  $\mu \times 95 \mu$ . In a specimen 5 mm. long the deposits are just a trifle larger, but in a fully-adult specimen, the anchors are 200–230  $\mu$  long and the plates are 165–185  $\mu$  long by 130–135  $\mu$  wide. The anchors thus just about double their

size as the animal matures, but the plates do not increase quite so much. A peculiarity of the plates not hitherto recorded is that the bridge is raised only a little above the surface of the plate and is attached to it anteriorly as well as posteriorly. The condition is thus intermediate between that of *S. nigra* and that which occurs in *Leptosynapta*. The connection between the anterior part of the bridge and the plate is easily overlooked in young or incompletely-developed plates, but it becomes well-marked in those which are old and fully formed. The miliary granules of *hydriformis* are minute rosettes about 10  $\mu$  across, but they occur in enormous numbers, often forming white spots in the skin. Naturally, they are much more abundant in old than in young specimens. They are often disintegrated into the minute grains, of which they are formed, by long preservation in alcohol, probably due to very slight acidity.

#### SYNAPTULA NIGRA.

Plate 3, fig. 3, 4; Plate 4, fig. 2.

*Synapta nigra* Semper, 1868. *Holothurien*, p. 12.

*Synaptula nigra* H. L. Clark, 1908. *Apod. hol.*, p. 81.

There are 6 specimens from Mer, Murray Islands, northeastern Australia. They were 100–350 mm. long in life, but though carefully narcotized before killing are only 70–225 mm. in their preserved condition. They agree perfectly with Semper's description, except that the black stripe on the tentacles, which he considered characteristic, is wanting in 5 specimens and only faintly indicated in the sixth. There is only one stone-canal, but there are numerous polian vesicles. The cartilaginous ring is very well developed with foramina near the posterior margin as in *Synapta*. The calcareous ring is white with no tinge of green. There is no indication of eye-spots. There are no supporting rods or other calcareous particles in the tentacles.

The calcareous particles are quite characteristic for although the anchors are much as in *hydriformis*, they are larger, while the plates and miliary granules are noticeably different. The anchors and plates show a considerable increase in size with the growth of the animal; in the smallest specimen, the anchors are 225–240  $\mu$  long and the plates are about  $175 \times 155 \mu$ , the width of plate being 88% of its length; in the next larger specimen, the anchors are 265  $\mu$  long and the plates are about  $205 \times 165 \mu$ ; in the largest specimen, the anchors run from 265 to 283  $\mu$  while the plates show even greater diversity, running from 185 to 228  $\mu$  in length while the width, usually less than 85% of the

length, may run to as much as 92%. Of course there is much diversity of size in both anchors and plates, but these figures represent the usual typical size in each of the specimens. The arms of the anchors are about 30% of its length, while their breadth is about 65%. The miliary granules are about 15  $\mu$  across.

## SYNAPTULA PSARA.

Plate 3, fig. 7, 8; Plate 4, fig. 5.

*Synapta psara* Sluiter, 1888. Nat. tijds. Nederl. Ind., 47, p. 219.

*Synaptula psara* H. L. Clark, 1908. Apod. hol., p. 84.

There is a single small specimen from SIBOGA station 273 at Pulu Jedau, Aru Islands. It was received labeled *lactea*, but it has all the characters of *psara* and must, I think, be referred to that species. It is only 37 mm. long and hence is obviously young. There are 13 unequal tentacles, ranging from 3 to 7 mm. in length. The calcareous ring shows no trace of green and the cartilaginous ring is well developed, much as in *nigra*. There is a single stone-canal and several, but not many, polian vesicles. The genital glands are fairly well developed for so small a specimen and are distinctly branched. There is a pair of small, but sharply-defined, eye-spots at the base of each tentacle, on the oral disk. There are no supporting rods in the tentacles, but miliary granules are more or less frequent there. The miliary granules in this species are peculiar, consisting of more or less complete circles of very minute spherical granules; with insufficient magnification each circle appears like a single piece. It is not impossible that in fresh material, the granules of a circle are united together, but that disintegration occurs easily in alcohol. This does not seem probable, however.

The anchors are 205–233  $\mu$  in length, with long, not widespread arms; their length is 38% of the anchor while their breadth is only 58%. The anchor-plates are 170–180  $\mu$  long by 120–140  $\mu$  in width. The teeth on the perforations are minutely rough at the tips, but whether this is natural or due to acid in the alcohol remains for further material to determine.

## SYNAPTULA RECTA.

Plate 1, fig. 13; Plate 3, fig. 9; Plate 4, fig. 3.

*Synapta recta* Semper, 1868. Holothurien, p. 14.

*Synaptula recta* H. L. Clark, 1908. Apod. hol., p. 84.

There are 48 specimens from four widely-separated localities.

A very large specimen, 425 mm. long as preserved, is from Ponape, Caroline Islands, where it was collected in 1877 by Rev. A. A. Sturgis. It is light yellowish brown in color and is noteworthy for having 14 tentacles. The digits are short, though the tentacles are long and slender. The anchors are 280-300  $\mu$  long.

There are 9 specimens from Friday Island, Torres Strait, 225-275 mm. long. Each has 13 tentacles, one or two of which may be shorter than the others. There are about 25 pairs of digits. Eye-spots at base of tentacles, on oral disk, are conspicuous on those specimens which are light colored anteriorly, but are indistinct in the darker ones. The color is nearly uniform deep brownish purple, but some specimens are lighter anteriorly, and one has the miliary granules so excessively abundant it is much lighter than the others. There are no supporting rods in the tentacles, but there are numerous small dense patches of miliary granules which appear as white spots in water or air, but are less conspicuous in alcohol. The calcareous ring is pure white. The cartilaginous ring is present, but not heavy, about as wide as the calcareous one. There is one stone-canal, but numerous polian vesicles. The genital glands are branched and the intestine is slender and looped as usual. The anchors are 245-275  $\mu$  in length; their arms are less than 40% of the length while the breadth of the arms is about 60% of the anchor-length. Some curious malformations occur among them, the two arms being asymmetrical and of unequal size, and occasionally a third arm is more or less developed. The plates are 190-210  $\mu$  long while their breadth is from 150 to 170  $\mu$  or even more; occasionally the breadth is 95% of the length. Anchors and plates occur in the basal part of the tentacles, but they are no smaller there than elsewhere. Many of these plates in the tentacles have marginal holes in addition to the normal seven, though the additional openings are especially frequent near the small end of the plate. Development of these marginal holes is associated with increased width of the plate and it is such plates which have the width 90-95% of the length. The miliary granules, which may be excessively abundant, are typical little rosettes, about 10  $\mu$  in diameter.

A specimen only 75 mm. long from Bantayan Reef, Cebu, Philippine Islands, was collected May 2, 1909 by Dr. L. E. Griffin. It was found among the "roots" of a "red gorgonian," and was very light brown mottled with white. There are 13 rather long tentacles with very short digits. The internal anatomy reveals nothing noteworthy. The calcareous particles are rather small, the anchors being only 200-235  $\mu$  in length.

The remaining 37 specimens are all small, 20-75 mm. long, but the largest is an anterior fragment of a specimen which was probably considerably longer. The lot, taken from a cable near Catbalogan, Samar, Philippine Islands, in September, 1912, by A. L. Day, show some very interesting growth-changes. There are 3 which have only 9 tentacles, 19 have 10 tentacles, (in one case 2 are noticeably smaller), 2 have 11 tentacles, 3 have 12, (in one case they are noticeably unequal), and 10 have 13, though in one case, one is very small; in another, 2 are very small; and in a third, 3 are very small. The internal condition of the specimens is very poor; in one specimen, the intestine seemed to be straight, without a loop, but the condition is too poor to permit of positive decision. In the smallest specimens, the anchors are 160-175  $\mu$  and the plates 135-150  $\mu$  long by 117-129  $\mu$  wide; the width of the plates is thus about 82-86% of the length; in the larger specimens, the plates are narrower, the width 78-81% of length.

#### SYNAPTULA RETICULATA.

*Synapta reticulata* Semper, 1868. *Holothurien*, p. 13.

*Synapta reticulata* H. L. Clark, 1908. *Apod. hol.*, p. 86.

A single specimen, supposed to be this species, is from SIBOGA St. 313, in Saleh Bay, Sumbawa, D.E.I. It is 22 mm. long with 10 tentacles, 2 mm. long. The calcareous particles are badly corroded, so that accurate identification of the specimen is not possible.

#### LEPTOSYNAPTA ACANTHIA.

Plate 6, figs. 12-16.

*Synapta acanthia* H. L. Clark, 1899. *Ann. N. Y. acad. sci.*, **12**, p. 126.

*Leptosynapta acanthia* H. L. Clark, 1908. *Apod. hol.*, p. 92.

The 11 specimens are from Bermuda: 3 cotypes, dissected and more or less cut to pieces, were collected in 1898; 7 are specimens I collected at Coney Island cove, in April, 1899; and 1 received in 1918 from the Bermuda Biological Station is without exact locality given. The largest specimen was about 350 mm. long and 8-10 mm. in diameter in life, a somewhat translucent pinkish white in color. This material shows no growth-changes in the calcareous particles. The large anchors are 600-650  $\mu$  long, with the arms 37% of the whole length, their breadth 50% of the anchor-length; there are usually 6-12 conspicuous teeth on each arm. The small anchors range from

140 to 210  $\mu$ , and often, perhaps usually, have 1, 2, or even 3 teeth on each arm; the arms are 34% of the anchor and their breadth is about 70%. The plates are from 130 to 175  $\mu$  in length and the larger are 125–130  $\mu$  wide and have 6 or more toothed perforations besides the small smooth ones. No intermediate stages between the large and small anchors were found.

LEPTOSYNAPTA CIRCOPATINA,<sup>1</sup> sp. nov.

Plate 4, fig. 6, 7; Plate 6, fig. 9–11.

Length about 22 mm.; diameter about 2 mm. Tentacles much contracted, but apparently 12, each with 5 digits of which the unpaired terminal digit is distinctly the longest, while the lower pair are only a trifle smaller than upper; there are 3 or 4 relatively large sense-cups on the inner face of each tentacle. No stone-canal or polian vesicle was found, nor was there any indication of a calcareous ring, but it seems probable that better material will show all of these organs. The anterior anchors are easily distinguishable from those at the posterior end. They measure about 95  $\mu$  in length and seldom attain 100; the arms are only 26% of the length, but their breadth is 60%; there are 2 minute teeth on each arm. The posterior anchors are 110–127  $\mu$  long and the arms are 26% of the length, but their breadth is only 44% of the anchor-length; there are 3 or 4 teeth on each arm. The anchor-plates show a corresponding difference in size, but it is less marked. Those at the anterior end of the body are 82–94  $\mu$  long and 73–80  $\mu$  wide; the width is thus nearly 90% of the length; they carry practically no bridge and are perforated with the usual 7 large holes, 2 smaller ones at the side of the narrower end and 3 little ones posteriorly. All of the perforations are smooth and only rarely does a low tooth occur on the margin of one of the larger ones. Posteriorly, the plates are about 100  $\mu$  long and 87  $\mu$  wide, and often have several small smooth holes in the margin external to the 7 large perforations. No miliary granules were detected in either the body-wall or the longitudinal museles, but relatively large tentacle-rods, over 50  $\mu$  long, more or less curved, expanded at each end, with a single perforation, and often a few short, rounded branches, there, are fairly numerous in the tentacles. Color (as preserved), yellowish brown.

HOLOTYPE.—M. C. Z. 38.

I collected a single specimen of this small species at Port Royal,

<sup>1</sup> *circus* = a circle + *patina* = a little plate, in reference to the form of the anchor-plates.

Jamaica, in December, 1902. It was found under a brick in the boat-canal which connects the "pond" back of Port Royal with Kingston Harbor. The color in life was pale, dull reddish. At the present time, there are very slight traces of decalcification, but as this has not affected the minute teeth on the anchor-arms, or the tentacle-rods, I do not think the absence of miliary granules and calcareous ring, or of teeth on the margins of the large perforations in the plates, can rightly be attributed to it. The size and form of the calcareous particles is very distinctive, but it is probable that this is a young specimen and when adults are procured, the anchors and plates will probably be larger and possibly show some modification of the form described and figured here.

LEPTOSYNAPTA CRASSIPATINA,<sup>1</sup> sp. nov.

Plate 6, fig. 1-4.

Length about 40 mm. in life; 25 mm. by 3, as preserved. Tentacles 12, with 4 or 5 pairs of digits and 4-10 large sense-cups on the inner surface of each. There is one slender polian vesicle but no stone-canal was detected. The calcareous ring is well developed with the radial pieces about half a millimeter wide and a third of a millimeter high, and perforated just above the middle for the nerve; the interradial pieces are narrower, but about as high and are deeply notched on the posterior margin. The anterior anchors are not only smaller than the posterior, but are different in form. They are 117-130  $\mu$  long, the arms only one fourth as much, but their breadth is 65% of the anchor-length; the arms are smooth or with slight indications of a single tooth on each. The plates, accompanying these anchors, are 110-117  $\mu$  long and 80-92  $\mu$  broad, relatively thick and heavy, with the usual 7 toothed holes, 2 large smooth holes, one on each side at the base of the bridge, and 6-8 small smooth holes beyond. There are 2 or 3 small holes in the base of the bridge on each side, the bridge itself being well developed. The posterior anchors are 155-183  $\mu$  long, with the arms nearly one third as much and their width about 45% of anchor-length. The arms have each 3-7 conspicuous teeth on the outer margin. The accompanying plates are very similar to those in the anterior part of the body and not very much larger, their measurements being about 130 by 90  $\mu$ . The longest plate measured is scarcely 140  $\mu$ . Miliary granules very characteristic, but not very abundant, often in groups of

<sup>1</sup> *crassus* = heavy, coarse + *patina* = a little plate, in reference to the relatively heavy anchor-plates.

3-5; they are curved rods with expanded and notched or branched tips; occasionally there is a knob, or even two, near the middle of the rod on the convex, and rarely on the concave, side. There are no special tentacle-rods, but numerous miliary granules occur in the tentacles, especially near the base. Color, in life and also as preserved, nearly white.

HOLOTYPE.—M. C. Z. 1188.

Two specimens of this synaptid were dug in sandy mud by a mangrove key near Key West, Florida, June 17, 1917, while I was collecting *Amphioplus*. The general appearance was so much like *inhaerens* of the same size that it was not until the calcareous particles were examined that the novelty of the specimens was appreciated.

#### LEPTOSYNAPTA DOLABRIFERA.

Plate 7, fig. 1-6.

*Synapta dolabrifera* Stimpson, 1856. Proc. Acad. nat. sci. Phil., 7, p. 386.

*Leptosynapta dolabrifera* H. L. Clark, 1908. Apod. hol., p. 89.

The 19 specimens of this characteristic Australian species at hand, all but one from Port Jackson, and all adult or nearly so, throw very little light on variation due to locality or age.

The single specimen from Torquay, Victoria, is the anterior end of a rather large specimen, mounted in balsam, and presented by Mr. E. C. Joshua in 1915. Its anchors and plates are somewhat larger than those of the Port Jackson specimens, but none of the latter are quite so big as it, so the difference may be only one of age. The differences in the size of the calcareous particles between the larger and smaller Port Jackson specimens is very slight, but this is probably due to their being adult. The anchors at the anterior end of the body are 10-20% smaller than those posteriorly, but the plates show only an inconsiderable difference. The Port Jackson specimens are 35-65 mm. long. Eight of them I collected at Watson's Bay, August 26, 1913, under stones near low-water mark. They were more or less translucent and were 50-80 mm. long.

Anteriorly the anchors vary from about 160 to over 200  $\mu$ , posteriorly from 200 to 250  $\mu$ . The anterior anchors have shorter and more spreading arms than the posterior ones and the teeth thereon are fewer and less conspicuous. The anchor-plates are relatively long and narrow, measuring 140-190  $\mu$  in length by 100-130  $\mu$  in breadth. The miliary granules anteriorly are, like those of *roscola*, C- and O-shaped,

but posteriorly are nearly straight rods. The tentacle-rods are only a little curved, 70–82  $\mu$  long, with expanded, perforated, notched, or slightly branched ends.

#### LEPTOSYNAPTA GALLIENNII.

Plate 11, fig. 1–5.

*Synapta galliennii* Herapath, 1865. Quart. journ. mic. sci., n.s. 5, p. 5.  
*Leptosynapta galliennii* H. L. Clark, 1908. Apod. hol., p. 91.

The M. C. Z. has 4 beautifully-preserved specimens, presented by Dr. Östergren, labeled "*Synapta bergensis* Östergren. Norge, Bergen, Mathopen (60° 20' N.), 5–15 m., mudder. 5/8, 1902. Hj. Östergren." Only one of the four is complete; it is 125 mm. long by 6 mm. in diameter and has 12 tentacles with 21 digits. One of the other specimens has 12 tentacles with 19 digits, but the other two are headless fragments. I am still of the opinion that *bergensis* is identical with *galliennii*.

The calcareous particles of the present specimens are typical. Anteriorly the anchors are about 675  $\mu$  long with their arms about 30% of that in length and 54% in width. The accompanying plates are about 500  $\mu$  long and 320 wide. But posteriorly the anchors are 800  $\mu$ –970  $\mu$  long with the arms one third that length, but less than half that in width. They have 7–9 prominent teeth on each arm whereas the anterior anchors have but 4 or 5. The posterior plates are 650–740  $\mu$  long by 420–475  $\mu$  wide and are notable for having several (typically 4) holes with dentate margins in the broad end beyond the usual 7. Near the narrow end the margin of the plate itself may be more or less dentate. The miliary granules in these Norwegian specimens seem to be confined to the anterior part of the radii, as I could find none elsewhere. They are relatively coarse, stout rods, usually C- or O-shaped, but often shaped like a club or a dumb-bell.

#### LEPTOSYNAPTA ICTINODES,<sup>1</sup> sp. nov.

Plate 7, fig. 7–11.

Length of preserved specimen about 45 mm.; diameter 5–6 mm. Tentacles 12 with 13–15 digits (6 or 7 pairs), the terminal longest; sense-cups unusually numerous (20–30). Owing to the condition of

<sup>1</sup> ἰκτινοειδής = kite-shaped, in reference to the form of the anchor-plates.

the specimen, it is not possible to determine the number of polian vesicles or of stone-canals. The calcareous ring is stout, about .70 mm. high, with the radial and interradial pieces similar and subequal, but the radial are perforated for the passage of the nerve and are a little more concave on the posterior margin than are the interradials. Anteriorly there is a well-marked peak on both radials and interradials.

Anterior anchors similar to those of the posterior end, but somewhat smaller, measuring 195–212  $\mu$  in length; the breadth across the arms is about 115  $\mu$  while the length of the arms is about 54  $\mu$ . Posteriorly the anchors are 235–247  $\mu$  with the width across arms about 130  $\mu$  and the arm-length about 70  $\mu$ . The anchor-arms are conspicuously dentate; on large anchors there may be as many as 9 teeth on each arm. The anchor-plates are about three fourths as long as the anchors and their width is about equal to three fourths of their length. They are remarkable for their lateral angles, which give them the form of a kite with the angles rounded. The larger the plate the more noticeable this kite-shape is, especially since the posterior end of the plate is more pointed in the larger examples. Another striking peculiarity of the plates is the abundant and large serrations of the margins of the large holes, the most anterior of which is conspicuously the largest. The narrow posterior end of the plate has about a dozen small, smooth perforations. The miliary granules are oval or elliptical in outline usually more or less constricted at the middle. They are very small, the largest only about 7  $\mu$  in length. The tentacle-rods are excessively numerous and occur even in the skin at the base of the tentacles. They are 42–80  $\mu$  in length and are more or less curved; at one extreme they are nearly straight save at the ends where the tips curve in abruptly; at the other extreme they are fully C-shaped. The tips are always more or less expanded and notched, and are often perforated. Color as preserved: very pale gray, but the body is covered with verrucae 150–200  $\mu$  in diameter and 180–225  $\mu$  high (more or less), which are full of lines and heaps of a dark, purplish brown, granular pigment. Posteriorly the verrucae are scattered and so widely separated they do not greatly affect the ground-color, but anteriorly they become more and more crowded until, just back of the tentacles the animal seems to be almost black. Of course, this crowding of the verrucae is partly, if not wholly, due to contraction of the body-wall. The pigment becomes bright rust-red in the presence of acid, but no visible effect is produced by an ordinary alkaline solution either before or after treatment with acid. The tentacles are cream-color in sharp contrast to the nearly black adjoining body-wall.

HOLOTYPE.—M. C. Z. 956.

Although this species is allied to *dolabrifera*, I think it must be quite distinct, for the color, the verrucae, the kite-shaped plates with their abundantly serrate holes, and the miliary granules are all very characteristic. A single specimen was collected at Westernport, Victoria, by Mr. J. Gabriel, who presented it to the M. C. Z. in November, 1913. It is probable that Mr. Joshua has met with this species, but did not distinguish it from *dolabrifera*, for in noting the color of that species (1914, Proc. Roy. soc. Victoria, n.s. 27, p. 7) he says, "One specimen from Wilson's Promontory was a deep, purple-black."

#### LEPTOSYNAPTA INHAERENS.

Plate 7, fig. 12-16.

*Holothuria inhaerens* O. F. Müller, 1776. Zool. Dan. Prod., p. 232.

*Leptosynapta inhaerens* Verrill, 1867. Trans. Conn. acad., 1, p. 325.

There are 187 specimens in the M. C. Z. which I refer to this species. They come from at least eleven different localities and show considerable diversity in the size of anchors and plates, so that a somewhat detailed account of them is necessary.

Four particularly fine specimens from Norway, the gift of Dr. Östergren, are labeled "*Synapta inhaerens* (O. F. Müll.) Norge, Moldöen, Degnepollen (61° 57' N.), 2-6 m., mudder. 8/14, 1902. Hj. Östergren." The largest is 125 mm. long and 7 mm. in diameter. In these specimens the anchors near the anterior end of the body are about 188  $\mu$  long and 110  $\mu$  across the arms which are about 75  $\mu$  long, while the accompanying plates are 155  $\mu$  long and 108  $\mu$  wide. Posteriorly, however, the anchors are 275-295  $\mu$  long, yet only 120  $\mu$  across the arms which are but 73  $\mu$  long.

Six specimens from Naples have been much cut to pieces, having served as material in several investigations. They are only of moderate size and one is very small, 20 mm. long by 1.75 mm. in diameter. The anterior anchors measure 172  $\mu$  in length, and 75  $\mu$  across the arms, which are about 40  $\mu$  long. The accompanying plates are 136  $\mu$  long by 103  $\mu$  wide. Posteriorly the anchors are 207  $\mu$  long, 82  $\mu$  across the arms, which are 52  $\mu$  long, and the plates are 148  $\mu$   $\times$  117  $\mu$ . In the little 20 mm. specimen the largest anchors and plates are just the size of the small ones in the large individuals.

Ten specimens from Massachusetts Bay are partially decalcified with curious results. These are cotypes of *Synapta gracilis* Selenka

and are of about average size (75–100 mm.). In one of the least decalcified specimens, the anchors average about 210  $\mu$  long by 105  $\mu$  wide and the arms are 68  $\mu$  long. The plates are 150  $\mu$   $\times$  105  $\mu$ .

From Provincetown, Mass., there are 64 specimens of average size, and condition, while from Nahant, Mass., there are 31 specimens of the same sort, but not so well preserved. These specimens call for no special comment as they are essentially like Woods Hole material. From that well-known biological Mecca, there are some 50 specimens in fairly good condition. The largest is nearly 150 mm. long and probably exceeded that measurement when alive. This is about the maximum size for American specimens of *inhaerens* though larger specimens may occur. In young specimens from Woods Hole the anterior anchors are only about 113  $\mu$  long, while the posterior are 153  $\mu$  long, and 70  $\mu$  across the arms, which are 40  $\mu$  long. In adult material from Woods Hole, however, the calcareous particles are 25% bigger; the anterior anchors are 140  $\mu$ , 85  $\mu$  across the arms which are 38  $\mu$  long; the accompanying plates are 125  $\mu$   $\times$  87  $\mu$ . Posteriorly the corresponding measurements are 207  $\mu$  by 100  $\mu$  for the anchors and 150  $\mu$  by 97  $\mu$  for the plates.

There is a single specimen from Mendocino, California, above average size, but badly cut to pieces. It is the only cotype of Selenka's *Synapta albicans* in the M. C. Z. The largest anchor found was 200  $\mu$  long, most are about 190  $\mu$ ; they are 82  $\mu$  wide across the arms which are about 45  $\mu$  long. The plates are 132  $\mu$  long by 94  $\mu$  wide.

Some 16 specimens from Pacific Grove, California, are of average size and in good condition. In these specimens the anterior anchors are about 150  $\mu$  long, while the accompanying plates are 118  $\mu$  long by 82  $\mu$  wide; the posterior anchors are 190–200  $\mu$  long and their plates 139  $\mu$   $\times$  100  $\mu$ . One specimen is remarkable for the very wide anchor-plates which measure about 130  $\mu$  by 110  $\mu$ ; some of these plates are widest back of the middle.

From an unknown locality, supposed to be on the Pacific coast of North America, south of San Diego, California, there is a bright brown leptosynaptid, which seems to be *inhaerens*. The posterior anchors vary from 143 to 170  $\mu$  in length and are noticeably narrow, only 63  $\mu$  across the arms which are 37  $\mu$  long. The anchor-plates are 100–115  $\mu$  long and about 84  $\mu$  wide. This specimen is supposed to have been taken by the ALBATROSS in 1911 and in 1913 it was "almost black," but has now become brown. It is only 35–40 mm. long by 4 mm. in diameter.

From Laguna Beach, California, a fragment of a leptosynaptid is

10 mm. long. It was "pink" in life, but shows no such color now. It was taken August 22, 1917. The anchors are 170-183  $\mu$  long, about 80  $\mu$  wide, across the 50  $\mu$  arms; the plates are about 130-135  $\mu$  by 90  $\mu$ .

Finally there are three fair adult specimens from Elly Bay, Belmullet, County Mayo, Ireland. These were sent to the M. C. Z. in July, 1920, by Miss Anne Massy, as part of the material upon which were based her remarks on *inhaerens* in her paper on Irish holothurians (1920, Sci. proc. Roy. Dublin soc., n.s. 16, p. 57). In these specimens the anchors range from 155  $\mu$  to 230  $\mu$  and the plates from 130  $\mu$  to 160  $\mu$ . Miss Massy's measurements as published indicate much larger calcareous particles than these for she says the anchors range from 176  $\mu$  to 330  $\mu$  (though only 2 exceeded 297  $\mu$ ), but about 70% are under 254  $\mu$ . She makes no distinctions of size or age nor of the anterior and posterior parts of the body. In a letter, however, she has kindly given measurements of 6 anchors from the anterior part of a 60 mm. specimen, and of 6 from near the posterior end; of the breadth across the flukes, as well as the length. According to these figures, the anterior anchors average 247  $\mu$  and the posterior 273  $\mu$ ; in each case the breadth across the flukes averages only 42% of the length. In measurements I made on the Elly Bay specimens, the breadth is about 45% of the length in the long posterior anchors, but is 57% of the length in the small anterior ones. Miss Massy's figures show some astonishing extremes for she gives one anterior anchor as 209  $\mu$  long by 110  $\mu$  broad (52%) and another, also anterior, as 313  $\mu$  long by 110  $\mu$  broad (32%). I do not find such diversity in the Irish material before me. Miss Massy's measurements average about 30% larger than mine. I can only account for our differences on the assumption of a large "personal equation" in measuring such minute objects, unless it should develop that Miss Massy did not make sure that all of the anchors she measured were fully mature, uninjured, and lying perfectly flat. The age of the specimen, (not always correlative with its size), and the part of the animal examined are, as already said, factors of great importance to which she gave no attention. There are also evidently considerable differences in the size of the calcareous particles in *inhaerens* from different localities, and many of Miss Massy's measurements are based on specimens from Blacksod Bay, whence I have had no material.

Comparison of the observations made on the material from the different stations listed above shows that the anchors anteriorly are usually about 140-160  $\mu$  long, while posteriorly they range from 170 to 295  $\mu$ , the marked diversity being associated in large part with age

and to some degree with locality. The plates show less diversity than the anchors and range from 115 to 160  $\mu$ ; the width of the plates is .65-.75 of the length. Of the material at hand, the Norwegian specimens have the largest calcareous particles, while the specimens from Ireland come next. Evidently then the *inhaerens* of northern Europe has distinctly larger anchors and plates than are found in American specimens. Specimens from Massachusetts Bay, Naples, and Woods Hole rank third, fourth, and fifth respectively, but the differences between the specimens from these three localities are trivial and seem to have no significance. The specimens from the Pacific coast of America seem to have somewhat smaller calcareous particles than those from the Atlantic coast, and those from the southern part of the western coast than those from farther north. The largest anchors of specimens from Laguna Beach and further south are hardly equal to the smallest anchors of the Norwegian specimens, but the intergradations between these two extremes is so complete it does not seem possible to separate *inhaerens* into either varieties or subspecies. It must be granted, however, that our knowledge of the Pacific coast leptosynaptids is still very imperfect.

#### LEPTOSYNAPTA LATIPATINA.

Plate 7, fig. 17-19.

H. L. Clark, 1921. Echin. Torres Strait, p. 161.

The only specimen of this species in the M. C. Z. is the holotype, the anterior end of which is lacking.

#### LEPTOSYNAPTA MULTIGRANULA,<sup>1</sup> sp. nov.

Plate 8, fig. 3-7.

Length, 75 mm.; diameter, 5 mm. Tentacles 12 with 5 or 6 pairs of digits; there are 2-9 sense-cups on the inner face of each tentacle. Stone-canal single with a well-marked madreporite. Polian vesicles 2-5, unequal; the largest 5 mm. long. Calcareous ring well developed, the radial pieces perforated for the passage of the nerve; both radial and interradial pieces, but especially the latter, deeply concave on the posterior margin; the anterior margin is slightly peaked especially on the radial pieces.

The anchors of the anterior end are 190-280  $\mu$  long, 115-148  $\mu$  across

<sup>1</sup> *multus* = many + *granulum* = a little grain, in reference to the very numerous miliary granules.

the 60-82  $\mu$  arms. The arms are well curved, but are not, even at the tip, nearly parallel to shaft. They each carry half a dozen well-marked teeth. The anchor-plates are somewhat shorter than the anchors; they average nearly 200  $\mu$  long by 150  $\mu$  wide; they have the usual 7 large serrate holes and half a dozen small smooth holes in the posterior end. The anchors near the rear end are much larger than those anteriorly placed; they range from 343  $\mu$  to 445  $\mu$ , but average about 390  $\mu$ . The arms are long and slender and near the tips are almost parallel with the shaft; they bear 9 or 10 conspicuous teeth. The width from tip to tip of arms is about 45% of the anchor-length, but the length of an arm is not quite one third the anchor-length. The posterior anchor-plates differ little from those of the anterior end, but some are distinctly larger; the largest are 285  $\mu$  long by 220  $\mu$  wide.

Miliary granules abundant all over the body and even in the tentacles; they are particularly abundant along the radii. They are relatively large, more or less irregular C-shaped bodies; anteriorly the tips are often a little expanded and notched, and rarely the whole granule is merely a thickened curved rod, which in extreme cases is almost straight; posteriorly the tendency is towards a reverse extreme, the two tips of the granule approaching each other and in extreme cases fusing to form doughnut-shaped particles. Anteriorly the granules are 25-40  $\mu$  long; posteriorly they are 18-28  $\mu$  long and 11-15  $\mu$  across. In addition to the miliary granules in the tentacles, there are a few more elongated particles which may be designated as tentacle-rods; they are about 40  $\mu$  long, quite slender, more or less curved, and have the ends expanded and notched; occasionally there is a tooth or short branch on the inner (concave) side, near the middle. Color in life, "delicate flesh-pink." Preserved material has the ground-color yellowish, with the tentacles and longitudinal muscles pale lemon-yellow; entire body-surface and outer surface of base of tentacles covered with low, ill-defined, minute, dull red verrucae. Under high magnification, the pigment is a light brick-red, but it varies more or less in shade. Some specimens have the yellow ground-color very pale and the verrucae very numerous and thus appear to be pale red with nearly white tentacles..

HOLOTYPE.—M. C. Z. 1,269.

This species is common at the Tortugas, Florida, where I collected twenty specimens in sandy mud among the roots of eel-grass on the southwest side of Loggerhead Key, in June, 1917. Its superficial resemblance to *inhaerens* is sufficient to let it pass as that species, if no careful examination were made.

LEPTOSYNAPTA MULTIPORA,<sup>1</sup> sp. nov.

Plate 9, fig. 1-5.

Length in life about 90 mm.; diameter about 4 mm. Tentacles 12, with 5 pairs of digits; terminal digit longest and basal pair shortest; there are about 20 sense-cups of moderate size on the inner surface of each tentacle. Owing to damaged condition of anterior end, no stone-canal or polian vesicle was found. Calcareous ring well developed, the radial pieces perforated for the passage of the nerve; both radial and interradial pieces are markedly concave on the posterior margin and slightly convex on the opposite side.

The anchors of the anterior end are very small, only 103-165  $\mu$  long, averaging about 140  $\mu$ ; they are about 83  $\mu$  broad across the short, thick arms which are only about 35  $\mu$  long; there are only 2 minute teeth on each arm. The accompanying plates are nearly as long as the anchors, ranging from 113 to 148  $\mu$  and averaging 139  $\mu$ ; the width is three fourths of the length, more or less. The plates have the usual 7-toothed holes, though the posterior one is small and the teeth are commonly wanting; the posterior end of the plate is exceptionally wide, but the number of perforations there is only about half a dozen as usual. The posterior anchors are very large and very different in form from those of the anterior end. They range from 280 to over 500  $\mu$  in length, but are for the most part over 400  $\mu$ . The arms are long, moderately slender and curved backward, but not nearly enough to become parallel with shaft; they are 150  $\mu$  long and 245  $\mu$  across from tip to tip in an anchor 450  $\mu$  long; each arm has 9 or 10 very conspicuous teeth. The plates accompanying these anchors are equally remarkable; they are 193-327  $\mu$  long and 136-200  $\mu$  wide. They have a dozen large, more or less dentate holes (the posterior, and even the most anterior may be smooth), the usual small smooth holes (a dozen or more) posteriorly, and several small dentate holes near the margin of the posterior end. When completely developed the large anchors and plates show little diversity in size or shape. These large anchors and plates are confined to the posterior part of the animal, but the small anchors and plates, abundant at, and characteristic of, the anterior end are to be found scattered sparsely among the big ones at the rear of the body. They are often very small there and in one case, the plate measured only 92  $\mu$  long by 70  $\mu$  wide. Miliary granules

<sup>1</sup> *multus* = many + *porus* = a passage or pore, in reference to the many perforations in the anchor-plates.

apparently wanting; none were detected anywhere. Tentacle-rods, few, slender and inconspicuous, forked or notched at each end. Color in life is recorded in my field-notes, as "a fine rose-colored *Synapta*"; the preserved specimen is a pale gray.

HOLOTYPE.—M. C. Z. 39.

This interesting leptosynaptid was dug in the sand at Drunkenman Cay, off Kingston Harbor, Jamaica, early on the morning of June 3, 1896. It was recognized at once as different from *inhaerens*, probably because of the color, but it was not critically examined for many years. No other specimens were taken that summer, nor have I met with it during my later visits to Jamaica, though I made a special trip to Drunkenman Cay in early December, 1902, for the purpose of getting more material. Although related to *acanthia*, it is quite distinct. The small anchors and plates are very similar to those of the Bermudan species, but are a little smaller, while the large anchors and plates are considerably smaller in *multi-pora*. The entire absence of miliary granules in the Jamaican form is an important difference between the two species and the small number of digits on the tentacles is noteworthy; this, however, may be associated with the much smaller size of the Jamaican specimen.

#### LEPTOSYNAPTA OOPLAX.

Plate 7, fig. 20-24.

*Synapta ooplax* von Marenzeller, 1881. Verh. K. k. zool.-bot. Ges. Wien, **31**, p. 122.

*Leptosynapta ooplax* H. L. Clark, 1908. Apod. hol., p. 24.

The only specimens of this species which the M. C. Z. possesses are two which were taken by the ALBATROSS at Funafuti, December 24, 1899. Neither of these is a perfect specimen, but the larger is 235 mm. long and only 4.5 mm. in diameter. It is flesh-color, in alcohol. The anchors, both anteriorly and posteriorly are about 148  $\mu$  long, but the anterior anchors have arms about 30  $\mu$  long and 80  $\mu$  across, whereas the anchors at the rear end have the arms about 35  $\mu$  long and only about 50  $\mu$  across. There are usually one or two minute teeth on each arm of either type of anchor. The anterior plates are about 115  $\mu$  long by 66  $\mu$  broad; they are more or less asymmetrical and the large holes seldom appear to form a circle of six around a seventh as is usual in *Leptosynapta*. Moreover the large holes are of unequal size and some of them at least, and often all, have smooth margins. The

plates accompanying the posterior anchors are more or less reduced in size; while usually about  $70\ \mu$  long by  $40\ \mu$  wide, they may be larger, but are often much smaller, plates less than  $50\ \mu$  long and with only a few large smooth holes being met with occasionally. A curious optical delusion results from this very unusual reduction of the posterior plates; the posterior anchors with their narrower and more gracefully-curved arms *seem* much longer than those near the anterior end, although actual measurements show that this is not the case. It is possible that von Marenzeller's statement that the posterior anchors are the longer rests in part on this appearance, though he gives the measurement of a posterior anchor as  $200\ \mu$ , a size not nearly approached by any of my material. Yet Ohshima (1914, p. 470) says the anchors in Japanese specimens range from 115 to  $195\ \mu$ .

LEPTOSYNAPTA PARVIPATINA,<sup>1</sup> sp. nov.

Plate 4, fig. 8, 9; Plate 6, fig. 5-8.

Length, 47 mm.; diameter, 3 mm. Tentacles 12 (in one specimen there are 13), with 5 pairs of digits; the terminal digit is distinctly the longest, and the basal pair shortest; there are 8-10 sense-cups on the inner surface of each tentacle. No stone-canal was detected, but a single long polian vesicle was present. Calcareous ring well developed, the radial pieces larger than the interradial, only slightly concave behind, but with a well-marked anterior peak and perforated for the passage of the nerve; interradial pieces deeply concave behind and slightly convex anteriorly.

The calcareous particles are all notably small. The anchors at the anterior end are only  $100-115\ \mu$  long; their arms are short and stout, about  $27\ \mu$  long and  $66\ \mu$  across from tip to tip; as a rule the arms are smooth, but occasionally a single minute tooth occurs on the outer margin near the tip. The plates accompanying these little anchors are  $94\ \mu$  long or less, their width being three fourths of their length or a little more; in form, they are very typical leptosynaptid plates, but the anterior large hole is often replaced by two and frequently there are little perforations present along the sides of the plate; even asymmetry of a pronounced type due to the unequal development of the perforations, is not rare. Posteriorly the anchors are about half as long again, ranging from  $136$  to  $165\ \mu$ ; their arms are  $42\ \mu$  long and  $73\ \mu$  from tip to tip, and bear 4 or 5 small teeth on their outer margins.

<sup>1</sup> *Parvus* = little + *patina* = a small plate, in reference to the small size of the anchor-plates.

Their accompanying plates are quite different from the anterior ones, being more elongated and elliptical, but they are not much larger; they are 103–110  $\mu$  long and 70–80  $\mu$  wide; the posterior end is nearly as wide as the anterior; the most anterior perforation is often conspicuously the largest. Miliary granules abundant in the bases of the tentacles and along the middle of the longitudinal muscles. They show great diversity in shape, ranging from simple disks to curved rods, enlarged and notched at the tips; some of the disks are perforated at the center; the granules are from 14 to 33  $\mu$ , but for the most part are under 25  $\mu$ . Tentacle-rods scarcely distinguishable from the elongated miliary granules, but a few, about 30  $\mu$  long, are recognizable by their slenderness. Color in life "translucent pinkish white"; in alcohol pale brown, almost dirty white. Two of the specimens are yellow, as a result of a mishap during their preparation at the Tobago laboratory.

HOLOTYPE.—M. C. Z. 1,268.

This species was fairly common in the sandy mud of what we called Sandy Point, in Buccoo Bay, Tobago. We took 15 specimens there March 29 and 30, 1916, by sifting spadefuls of the muddy sand. The largest one seen was about 150 mm. long when fully extended, but was very slender and quickly broke in two. Most of the specimens were much smaller than this; one has 13 tentacles, but all of the others have 12. This 13-tentacled specimen is, in its preserved condition, about 40 mm. long and 2.5 mm. in diameter, which is apparently an indication that it is mature.

#### LEPTOSYNAPTA ROSEOLA.

Plate 7, fig. 25–28.

Verrill, 1874. Invert. anim. Vineyard Sound, p. 362.

This species, originally described from the Woods Hole region, is poorly represented in the M. C. Z. There is a good lot of 28 specimens from Bermuda, collected in April, 1899, but there is only a single small specimen from Woods Hole. There are two very small synaptids from Port Antonio, Jamaica, one an anterior fragment, the other minus the head, which are best referred to *roseola*. Both are in poor condition, but they are not decalcified and the anchors are like those of *roseola* but are small, only 117–130  $\mu$  long. My Jamaica field-notes contain this entry concerning one of these specimens: "Under a rock on Titchfield Point reef, I found a small *Synapta* about half an inch

long. It was a light flesh-color, thickly covered with dark reddish brown spots on tubercles."

Comparison of the Woods Hole and Bermuda specimens of *roscola* show a remarkable identity in the size of the anchors. Anteriorly they are about 140  $\mu$  in length, with arms 37  $\mu$  long and about 75  $\mu$  across. The posterior anchors are usually larger, ranging from 160 to 170  $\mu$ , with arms 42  $\mu$  long and only about 70  $\mu$  across. The plates are about the same size in all parts of the body, averaging about 118  $\mu$  by 82  $\mu$ , but larger plates do occur posteriorly. These figures indicate that these specimens are not so old as the ones I examined at Woods Hole in 1898, in which the contrast between the anterior and posterior calcareous particles was much more marked.

#### LABIDOPLAX BUSKII.

Plate 4, fig. 10; Plate 8, fig. 8-10.

*Synapta buskii* McIntosh, 1866. Proc. Roy. soc. Edinburgh, 5, p. 611.

*Labidoplax buskii* Östergren, 1903. Bergens mus. Aarb. 1902, no. 9, p. 12.

There are 6 specimens of this curious little synaptid in the M. C. Z., but half of them are completely decalcified; three are beautifully preserved, 18-24 mm. long, each with 11 well-expanded tentacles and no calcareous parts; the body-wall is translucent and the color is nearly white. They are from Kristineberg, Sweden, taken in July, 1905, and presented by Dr. Östergren. Of the other specimens, one is 8 mm. long and about a millimeter in diameter. It is light brown, has 11 tentacles and was dredged off Lofoten, Norway, in 200-300 fms. It is a donation from Professor Sars. The other two were taken in the Kattgat at 5 fms. and were received in exchange from the Copenhagen Museum in 1907. Each of these has 11 tentacles, in one case greatly contracted, but in the other fully expanded. There are no calcareous particles, decalcification having occurred.

The calcareous particles of the Norwegian specimen are thus the only ones I have examined. The anchors are 170  $\mu$  long, which is in accordance with Östergren's figures. They have arms nearly 50  $\mu$  long and nearly 80  $\mu$  across, which seem to be perfectly smooth, although Östergren says there are usually "3-5 small" teeth on each arm. The plates are about 140  $\mu$  long and 113  $\mu$  wide. They are quite symmetrical and show little diversity. The chief difference one sees among them is in the "handle" where the two perforations show

considerable variety of size and form, and occasionally merge into one long slit.

In my diagnosis of *Labidoplax* (1908, Apod. hol., p. 94) I have called the tentacles "digitate," as they obviously are in the larger species, but in the finely-preserved specimens of *buskii* from Kristineberg it is clear that the tentacles are pinnate with a single pair of digits, much smaller than the terminal digit. This is an entirely different sort of tentacle from that of *digitata*, and would suggest that the two species are not congeneric. But the larger Norwegian species (*media*) has really digitate tentacles and yet is obviously too much like *buskii* to be placed in a different genus. If it should be ultimately shown that *media* is the adult of *buskii*, the tentacles of the latter would surely be a most interesting growth-stage, showing the transition from pinnate to digitate tentacles.

#### LABIDOPLAX DIGITATA.

##### Plate 10, fig. 2-6.

*Holothuria digitata* Montague, 1815. Trans. Linn. soc. London, **11**, p. 22.  
*Labidoplax digitata* Östergren, 1898. Öfv. K. vet.-akad. Förh., **55**, p. 116.

There is only a single specimen of *Labidoplax* in the M. C. Z. which can be referred to this species, if *thomsonii* is to be kept separate, and even in this there are no "giant" anchors. The specimen is supposedly from Naples as it was received from the Naples Zoölogical Station many years ago. It is 125 mm. long by 13 mm. in diameter and has 12 tentacles, each with two pairs of long digits. Some sense-cups are present on the tentacles, but they are not conspicuous. The anchors of the posterior end are 165-175  $\mu$  long and 135-150  $\mu$  across the arms from tip to tip. Thus the width of the anchor is only about 82-86% of their length. The arms seem to be smooth with no indication of marginal teeth. The anchor-plates are about 150  $\mu$  long and their width is 63-70% of the length. They have three large smooth holes across the anterior end, the middle one largest and back of it is a similar large hole; there are many other (18-20) small holes of diverse size and situation at the sides and posterior end of the plate; the surface of the plate is smooth, only rarely with a rough projection.

## LABIDOPLAX DUBIA.

Plate 8, fig. 11-14; Plate 11, fig. 8.

*Synapta dubia* Semper, 1868. Holothurien, p. 10.*Labidoplax dubia* Östergren, 1898. Öfv. K. vet.-akad. Förh., 55, p. 116.

The only indubitable specimen of this species in the M. C. Z. is one of those taken by the ALBATROSS off eastern Japan (Station 3,723) in 13-16 fms. It is 65 mm. long by 4 mm. in diameter. The anchors (posteriorly) are 165-188  $\mu$  long with arms 48-57  $\mu$  long and 75-80  $\mu$  across, while the plates are 125-140  $\mu$  long with a width varying from 54 to 68 per cent of the length. Théel (1886, p. 14) gives the length of the anchors as 130-180  $\mu$  with the plates 100-112  $\mu$ , the width almost exactly half their breadth. Ohshima (1914, p. 471) says the anchors are 110-155  $\mu$  long and the plates 90-140  $\mu$ . It will be noticed that Ohshima's measurements of the plates show a range great enough to include both Théel's and mine, but his anchors are markedly smaller, his maximum not equalling my minimum. Théel's measurements, however, overlap both Ohshima's and mine very broadly and leave no doubt that the differences in our figures are due to the diversity shown by our specimens, a diversity by no means extraordinary. But the figures given in my Apodous holothurians (1908, p. 96) are about 30% greater for the anchors and 50% greater for the plates than the measurements here given, based on a specimen from the same lot. It is probable that some mistake was made in my earlier measurements, but it is possible that the specimen first examined was the oldest of the lot and really had exceptionally large anchors and plates. One point in favor of this latter explanation is that the measurements given fifteen years ago show that the plates were not only unusually long, but proportionately very narrow (only 41-44% of the length), as though they had continued their longitudinal growth beyond normal without increasing the normal width.

There is a headless fragment of a synaptid in the M. C. Z., taken in Tokyo Bay by E. S. Morse, many years ago, the calcareous particles of which show that it belongs in the genus *Labidoplax*. It is about 15 mm. long by 6 mm. in diameter, but it is difficult to decide what the normal size of the whole animal was. The color is brownish white. There are no miliary granules present. The anchors are about 118  $\mu$  long by 75  $\mu$  across the arms, which are usually smooth, but may have a tooth, or even two, on the outer margin. The plates (Pl. 11, fig. 8) are remarkably short and wide, about 100 by 75  $\mu$ ; there are three large

perforations, two somewhat smaller and about eight little ones, besides the long slit in the "handle." While these anchors and plates are thus much shorter and wider than any I have seen in *dubia*, it seems that Ohshima has examined specimens of that species with calcareous particles as small as these, and I have therefore decided to regard this Tokyo specimen as a fragment of a young *dubia*.

#### LABIDOPLAX THOMSONII.

Plate 9, fig. 6-10; Plate 10, fig. 1.

*Synapta thomsonii* Herapath, 1865. Quart. journ. mic. sci., n.s. 5, p. 6.

*Labidoplax thomsonii* Östergren, 1898. Öfv. K. vet.-akad. Förh., 55, p. 116.

The five specimens, sent as *digitata* from the Naples Zoölogical Station and referred to this species, (Apodous holothurians, 1908, p. 97), are the only specimens of *thomsonii* in the M. C. Z. All are fully adult, the largest measuring 220 by 12 mm. They lack sensory-cups and "giant" anchors and the anchor-plates are similar to those which Ludwig describes as characteristic of *thomsonii*. The tentacles seem to be longer with relatively shorter digits than in *digitata* and the anchors show a very constant difference of form. The shaft of the anchor is relatively shorter and the stock heavier, so that the width across the arms from tip to tip equals (or nearly so) and often exceeds the length of the anchor. In the specimen, considered *digitata*, the stock in extreme width is less than one third the anchor-length, while in these *thomsonii* it is more than one third and may be one half. The anchor-arms are usually smooth, but occasionally have 1, 2, or 3 small teeth. The anchor-plates at the anterior end are essentially like those of *digitata*, but posteriorly they are obviously different; they are relatively wider, with a much more irregular margin, a rougher and more irregular surface, and fewer, (relatively), smaller perforations. The plates are about as long as the anchors and their width is about four fifths of their length. A typical anchor is 120  $\mu$  long, 136  $\mu$  across the arms, and 66 mm. across the stock. The plate is about 140  $\mu$  long, (including handle), and 116  $\mu$  wide, the handle being 42  $\mu$  long and 49  $\mu$  wide. It seems to me exceedingly doubtful whether *digitata* and *thomsonii* are really distinct, but just what the relation of the two forms is remains to be made clear. Comparative study of a large series of specimens of diverse sizes, from the vicinity of Naples, would probably solve the problem.

## PROTANKYRA ABYSSICOLA.

Plate 11, fig. 6, 7; Plate 12, fig. 1.

*Synapta abyssicola* Théel, 1886. CHALLENGER hol., p. 14.*Protankyra abyssicola* Östergren, 1898. Öfv. K. vet.-akad. Förh., 55, p. 117.

As this deep-sea synaptid is always strongly contracted when it reaches the surface, and commonly more or less in fragments, it is not strange that such material as there is in the M. C. Z. is in very unsatisfactory condition. There are three lots of fragments, one from off the coast of Peru in 2,222 fms. (ALBATROSS St. 4,651), one from off Point San Tomas, west coast of Lower California, in 1,090 fms. (ALBATROSS St. 5,673), and one from off New Jersey, in 1,394 fms. (BLAKE St. 340).

The Peruvian material seems to be made up of parts of four specimens, about 150 mm. in length. They were discussed by me briefly (1920, Mem. M. C. Z., 39, p. 124).

The specimens from off Lower California include two head-ends, so those fragments probably represent two specimens, briefly described in Bull. Amer. mus. nat. hist., 1913, 32, p. 227. The two heads each show 12 tentacles, but the digits are so strongly contracted their form and even their number is uncertain, though there is no reason to doubt that the usual two pairs are present. The anchors are all more or less broken, but three that permitted measurement were 700-750  $\mu$  long with arms, 180  $\mu$  long and 325  $\mu$  across from tip to tip. The arms as a rule appear smooth, but careful examination with high power reveals 2 or 3 teeth on each arm, in several of the anchors. The plates are 575  $\mu$  long by 475  $\mu$  in width and have about 50 holes of which the larger ones have conspicuously dentate margins.

The New Jersey material consists of a headless fragment labeled "*brychia* Verrill." The anchors are nearly 770  $\mu$  long with arms about 300  $\mu$  long and only about 375  $\mu$  from tip to tip; there are 5 or 6 conspicuous teeth on each arm. The plates are about 735  $\mu$  long by 575  $\mu$  wide and are perforated by numerous small dentate holes. While these anchors and plates are exceptionally large for *abyssicola*, they are not nearly so large as in typical *brychia*. Moreover, the plates are shaped like those of *abyssicola* and do not resemble those of *brychia*. I think therefore this fragment from the western Atlantic must be considered an anomalous *abyssicola*.

In my Apodous holothurians (1908, p. 25, 99, and 103, and explanation of Plate 4), seemingly contradictory statements occur in re-

gard to miliary granules in *brychia*. Thus the statement is first made that "miliary granules" occur "along the radii," and again that "accessory calcareous bodies" are present, while on p. 103 there is the definite assertion that "there are no accessory calcareous bodies in the skin." In the explanation of Plate 4, fig. 14 is said to represent the "miliary granules" of *brychia*. The truth is that the only accessory calcareous bodies in *brychia* are the elongated disks and oval rods which occur beneath the longitudinal muscles "along the radii." They do not occur elsewhere "in the skin" and are thus very different, in distribution at least, from the calcareous particles of *Euapta* and other genera, which are known as "miliary granules." But in *Leptosynapta* some species have miliary granules scattered abundantly in the skin, while in others they are confined to the radii, and in others they seem to be wanting. Hence it would seem to be necessary to call all the accessory calcareous particles of the body-wall, "miliary granules," regardless of their distribution. There is no essential difference between *abyssicola* and *brychia* in this particular so far as the material which I have seen shows.

PROTANKYRA BIPEDATA,<sup>1</sup> sp. nov.

Plate 8, fig. 1, 2; Plate 10, fig. 7.

Length of fragment, 35 mm.; diameter, 4-5 mm. Anterior end missing. Anchors symmetrical, about 550  $\mu$  long, with arms 150-160  $\mu$  long, and 425  $\mu$  across from tip to tip; each arm has half a dozen sharp conspicuous teeth on the outer margin near tip. The stock has each side constricted basally so that it is somewhat foot-like in appearance, and each of these "feet" is covered on the lower half and distal end with minute projections, making the surface rough. The anchor-plates are equal to or even exceed the plates, some of them measuring 590 by 500  $\mu$ ; they are widest close to the distal (or anterior) end and are perforated with numerous serrated holes. Miliary granules are very abundant all through the skin; they are fundamentally C-shaped, but the degree of curvature shows some diversity and there is great difference in the relative width of the curved rod itself in different granules. They range in size, (length), from 20 to 50  $\mu$ .

HOLOTYPE.—M. C. Z. 47.

This fragment was received from the Amsterdam Museum in 1907 as having been collected at SIBOGA St. 306, which was off the east

<sup>1</sup> *bipedata* = having two feet, in reference to the form of the anchor-stock.

end of Flores in 137 fms. It is labeled *P. ludwigii* Sluiter, but it is hard to see how it can possibly be assigned to that species. For the anchors in *bipedata* are symmetrical and according to the original description and figures of *ludwigii*, "die Ankerarme sind unsymmetrisch." In *bipedata* there are no accessory perforated plates in the body-wall whereas these are well developed and very characteristic in *ludwigii*. Finally the miliary granules are very different from those of *ludwigii* as figured by Sluiter (1890, Pl. 5, fig. 7, 8).

In his account of the holothurians collected by the SIBOGA, Sluiter (1901, p. 130) says that the anchors and plates of the fragments from St. 306 agree "genau" with his earlier example of *ludwigii*, but the miliary granules are different. Strangely enough he makes no reference to the remarkable perforated plates of *ludwigii*, which are quite wanting in this fragment from St. 306. The SIBOGA took 4 synaptids at St. 294 which Sluiter asserts are "without doubt" *ludwigii*, but he does not mention the perforated plates or the amount of asymmetry in the anchors. Further information on these points is much to be desired.

Since this fragment from St. 306 is certainly not *ludwigii*, the question arises whether it might not be referred to some other known species. It is undoubtedly rather nearly related to *insolens* Théel, but the anchor-arms have not nearly so many teeth and the miliary granules are entirely different. Under the circumstances therefore I think this fragment from Flores must be made the type of a new species.

#### PROTANKYRA SIMILIS.

Plate 9, fig. 11; Plate 12, fig. 2-6.

*Synapta similis* Semper, 1868. Holothurien, p. 10.

*Protankyra similis* Östergren, 1898. Öfv. K. vet.-akad. Förh., 55, p. 117.

The M. C. Z. is fortunate in having two specimens of this synaptid, one of which is certainly, and the other probably, one of Semper's types. The former is labeled Bohol, Philippine Islands, the latter simply Philippines. It is interesting to find that each has 12 tentacles and hence Semper's statement that there are only *ten* is probably a slip of the pen. The preserved specimens are about 70 mm. long by 8 mm. in diameter, and except for the number of tentacles conform well to Semper's description. The tentacles are remarkable from the fact that in addition to the two pairs of terminal digits, there is a distinct, but undeveloped digit present on each side. I have not noticed

such digits in any other member of the genus. Semper gives the anchors as  $357 \mu$  long with arms about  $115 \mu$  long and  $230 \mu$  across from tip to tip. I find the anterior anchors distinctly smaller than this ( $277 \mu$ ), but posteriorly they may be considerably larger, the largest I have measured being  $430 \mu$  long; these large posterior anchors have 9 or 10 incurved teeth on each arm, and their stock is over  $180 \mu$  across. The anchor-plates, anteriorly  $263 \mu$  long by  $230 \mu$  wide, posteriorly  $357 \mu$  by  $300 \mu$ , are notable for their numerous, rather small perforations with entire, smooth margins. The miliary granules are abundant all over the body-surface; they are  $42-70 \mu$  long and are clearly forked at each end; they may be quite distinctly curved in the plane in which the fork lies; rarely each fork shows indications of having each of its branches forked. There are no real supporting rods in the tentacles, but in the wall of the tentacle itself there are very numerous elongated, oval bodies, more or less constricted at the middle, about  $20-30 \mu$  long and  $7-8 \mu$  wide. These are also present in the digits, but not at all commonly.

#### ANAPTA.

This genus was established in 1868 by Semper for a Philippine synaptid, which lacked anchors and plates, at that time the diagnostic character of *Synapta*, and also lacked the calcareous wheels characteristic of the only other genus in the family, *Chiridota*. Besides this negative character, *Anapta* is shown, by Semper's beautiful figures and careful description, to possess 12 pinnate tentacles as in *Synapta*, and other features which distinguish it as a well-marked genus. Additions to the genus were made by Sluiter in 1888 and Lampert in 1889 and their species are undoubtedly congeneric with and closely allied to Semper's genotype. But in 1892, Ludwig took the unfortunate step of making the absence of wheels and of anchors the one diagnostic feature of *Anapta* and included five synaptids in the genus, which agreed in this particular. It is true he gives "12 tentacles" as a feature of the genus, but he takes no account of the character of the tentacles, and in my judgement this is a very fundamental point in synaptid morphology. Naturally later writers followed Ludwig and species were added to the genus, which have little in common with Semper's Philippine species. In my *Apodous holothurians* (1908) I endeavored to give proper weight to the character of the tentacles, and suggested the genera *Dactylapta*, *Scoliodota*, and *Achiridota* for species which had been placed in *Anapta*, but which are really not

closely allied to it. Before he had had an opportunity to know of my publication a young Russian, M. Britten, published (1908) a paper on holothurians from Japan and the Okotsch Sea, in which he described two additional species of *Anapta*, assigning them to that genus solely because of the absence of wheels and anchors. In 1912, the M. C. Z. fortunately secured cotypes of Britten's species from the St. Petersburg Museum, and I have thus been able to examine some of his material. Of his *Anapta amurensis*, one specimen is in fair condition, 23 mm. long and 6-7 mm. in diameter, taken on sandy mud in 2½ fms. at the mouth of the Amur River. The color is nearly white. There are 12 *palmate* tentacles, each with 5 pairs of digits. The specimen is wholly decalcified and there is not even a calcareous ring. Britten notes the absence of a calcareous ring and it seems extraordinary that he apparently never suspected decalcification. He says that some of the specimens were a "fine rose-red." There is no doubt that these so-called *Anaptas* are *Chiridotas* and it seems highly probable that they are *C. laevis*. Of *Anapta ludwigi* Britten, the M. C. Z. has one specimen taken July 11, 1899, on a muddy bottom in 20-25 fms. off Poro Tomari, west coast, southern Sakhalin. Careful examination of this specimen has revealed two wheel-papillae from which the wheels had been completely dissolved out. The whole appearance of this specimen, but especially the tentacles shows that it is a *Chiridota*, and I have little doubt that it is *C. discolor*. Britten's specimens were more or less decalcified, but probably in most of them the wheel-papillae had simply been rubbed off during the rough treatment in the dredge, leaving no trace of the characteristic wheels.

*Anapta* thus contains only the three species described before 1890, and of them our knowledge is very imperfect.\* No further specimens of Sluiter's East Indian species, *subtilis*, have been reported since the holotype was described and it is quite possible that that was an aberrant synaptid of some other genus. The other two species are represented in the M. C. Z. collection.

#### ANAPTA FALLAX.

Lampert, 1889. Zool. jahrb. Syst., 4, p. 848.

The only specimen that the M. C. Z. possesses of this South American species is a little fragment, 6-8 mm. long by a couple of millimeters thick, which has been considerably cut to pieces. It was taken by the ALBATROSS (Station 2,784) in 194 fms., (an excessive depth), off the

southern end of South America, lat.  $48^{\circ} 41' S.$ , long.  $74^{\circ} 24' W.$ , and was discussed briefly in Apodous holothurians (1908, p. 26). It is unfortunate that Ludwig, who had some good material from a number of stations, never stated in just what way *fallax* is to be distinguished from *gracilis*. The difference is by no means clear and the material available does not permit my throwing any light on the matter. The present specimen seems to have no calcareous particles either in the tentacles or along the radii.

ANAPTA GRACILIS.

Plate 12, fig. 7, 8.

Semper, 1868. Holothurien, p. 17.

The M. C. Z. possesses one of Semper's cotypes taken near Manila. It is only an anterior fragment, 20 mm. long by 6 mm. in diameter, with 12 tentacles, mostly with 11 digits, but the number ranges from 9 to 13. The color is brown with the digits, oral disk, and very numerous verrucae nearly white. The sense-cups along the sides of the tentacles are very minute and would easily be overlooked with an ordinary lens. The calcareous particles in the verrucae are very small, 16-27  $\mu$  long and 5-10  $\mu$  thick. Their surface is not smooth, but very finely rough with minute points. This characteristic of the granules is not mentioned by Semper and he gives no figures. It is possible that it is due to the first indications of acid in the alcohol, which ceased with change of the preserving fluid, but it is so uniformly evident that it seems normal.